Unit 10 · Metallurgy

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 42

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Spot the errors

ANSWER U · 3

1. Fe_2O_3 has two iron atoms: iron is 112/160 of it. $500 \times 112 \div 160 =$ **350 kg**.
2. The equation isn't balanced: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$, so **3 mol** of CO for each mole of Fe_2O_3.
   (500 kg of Fe_2O_3 is 3,125 mol, so it needs 9,375 mol of CO, 210 m^3 at STP.)

MARKING SCHEME

- ✓ Iron is 112/160 of Fe_2O_3.
- ✓ 350 kg of iron.
- ✓ $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$: 3 mol CO.

2 Five metals, three tests

ANSWER A · 5

i. **A aluminium, B iron, C copper, D silver, E gold.**
ii. $Fe + 2HCl \rightarrow FeCl_2 + H_2$.
iii. $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$; the colorless NO meets air and becomes brown NO_2: $2NO + O_2 \rightarrow 2NO_2$.
iv. Silver forms silver chloride, which is insoluble and coats the metal.

MARKING SCHEME

- ✓ A, B and C named.
- ✓ D and E named.
- ✓ $Fe + 2HCl \rightarrow FeCl_2 + H_2$.
- ✓ NO formed, oxidized in air to brown NO_2.
- ✓ An insoluble AgCl coat stops it.

3 Which rock?

ANSWER A · 4

i. P: $500 \times 112 \div 160 =$ **350 kg**. Q: $400 \times 168 \div 232 =$ **290 kg**. S: $900 \times 56 \div 116 =$ **434 kg**.
ii. **Rock S**, though siderite is the poorest of the three minerals.
iii. **Magnetite** (72.4%).
iv. Removing its sulphur costs too much, and the sulphur dioxide pollutes the air.

MARKING SCHEME

- ✓ 350 kg from P.
- ✓ 290 kg from Q and 434 kg from S.
- ✓ Rock S gives most; magnetite is the richest mineral.
- ✓ Sulphur: costly to remove, and SO_2 pollutes.

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4 Work backward

ANSWER HA · 4

Let x mol Al and y mol Fe. $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$ gives 1.5x mol H_2; $Fe + 2HCl \rightarrow FeCl_2 + H_2$ gives y.
Mass: $27x + 56y = 8.3$. Hydrogen: $1.5x + y = 5.6 \div 22.4 = 0.25$.
So $y = 0.25 - 1.5x$; $27x + 56(0.25 - 1.5x) = 8.3$; $14 - 57x = 8.3$; **$x = 0.1$, $y = 0.1$**.
Aluminium: $0.1 \times 27 =$ **2.7 g**; iron: $0.1 \times 56 =$ **5.6 g**.

MARKING SCHEME

- ✓ The two equations: 1.5 mol H_2 per mol Al, 1 per mol Fe.
- ✓ $27x + 56y = 8.3$ and $1.5x + y = 0.25$.
- ✓ $x = 0.1$, $y = 0.1$.
- ✓ 2.7 g of aluminium, 5.6 g of iron.

5 How many carats?

ANSWER HA · 4

i. $23.3 \div 1.30 =$ **17.9 g/cm^3**.
ii. Gold: $g \div 19.3$; copper: $(23.3 - g) \div 8.93$.
iii. $g \div 19.3 + (23.3 - g) \div 8.93 = 1.30$. $0.0518g + 2.609 - 0.1120g = 1.30$, so $0.0602g = 1.309$ and **$g \approx$ 21.7 g**.
iv. $21.7 \div 23.3 = 0.93$; $0.93 \times 24 \approx$ **22 carat**.

MARKING SCHEME

- ✓ 17.9 g/cm^3.
- ✓ The two volumes in terms of g.
- ✓ $g \approx 21.7$ g.
- ✓ About 22 carat.

6 Which explanation fits the evidence?

ANSWER HA · 3

Kriti's. If aqua regia were just a stronger acid, silver, which already dissolves in nitric acid, would dissolve in it too; it stops because its chloride is insoluble, so chloride's part is to join the metal ions. Gold needs both: nitric acid to take its electrons and chloride to hold the ions, which is why neither acid works alone.

MARKING SCHEME

- ✓ Kriti's explanation.
- ✓ Silver: a stronger acid would dissolve it; chloride's role shows in the AgCl skin.
- ✓ Gold needs both: oxidizing by HNO_3, holding by Cl^-.

7 What if?

MARKING SCHEME A · 3

- ✓ No slag forms; the gangue stays.
- ✓ FeO joins the sand, wasting iron.
- ✓ The iron is no longer protected from the blast.

8 Count the electrons

MARKING SCHEME A · 3

- ✓ 3 electrons given, 3 taken.
- ✓ Three nitrates unchanged.
- ✓ 0.747 L.

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9 Choose the metal

MARKING SCHEME U · 3

- ✓ Gold, as it never corrodes.
- ✓ Iron, as it is magnetic.
- ✓ Aluminium, light and a good conductor.

10 Correct the misconceptions

ANSWER U · 3

1. Most of the reducing is done by **carbon monoxide** made from the coke; the coke mainly burns to give heat.
2. The zone of reduction is near the **top**, the coolest part (400–700 °C); the hottest, at the bottom, is the zone of combustion.
3. Pig iron is hard and **brittle**: it breaks when hammered.

MARKING SCHEME

- ✓ Carbon monoxide does most of the reducing.
- ✓ Reduction near the top, the coolest; combustion at the bottom.
- ✓ Pig iron is brittle.

11 Estimate

ANSWER A · 3

1,000 kg of iron is 1,000,000 ÷ 56 = 17,860 mol; each 2 mol Fe needs 3 mol of the gas, so 26,790 mol.

i. 26,790 × 2 g = **about 54 kg** of hydrogen.
ii. 26,790 × 18 g = **about 482 kg** of water.
iii. 26,790 × 44 g = **about 1,180 kg** of CO_2.

MARKING SCHEME

- ✓ About 54 kg of hydrogen.
- ✓ About 482 kg of water.
- ✓ About 1,180 kg of CO_2.

12 Think

ANSWER HA · 2

Thickness = 0.0001 mm = 0.00001 cm. Area = volume ÷ thickness = 0.604 ÷ 0.00001 = 60,400 cm^2, **about 6 m^2**, the floor of a small room.

MARKING SCHEME

- ✓ Thickness in cm: 0.00001 cm.
- ✓ About 60,400 cm^2, 6 m^2.

13 Make your own

ANSWER HA · 2

For example: “Why can concentrated nitric acid be carried in aluminium tanks, though aluminium is light and reactive?” Concentrated nitric acid makes aluminium passive by forming an oxide film, and aluminium is light enough to make large tanks.

MARKING SCHEME

- ✓ A question using a property and a reaction.
- ✓ A correct answer.

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See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **The Giant Periodic Table** (exhibit): Turn the cubes of iron, copper, silver and gold: each shows a use, steel structures, electric wires, jewelry, that fits the metal's properties.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	0	9	18	15	**42**